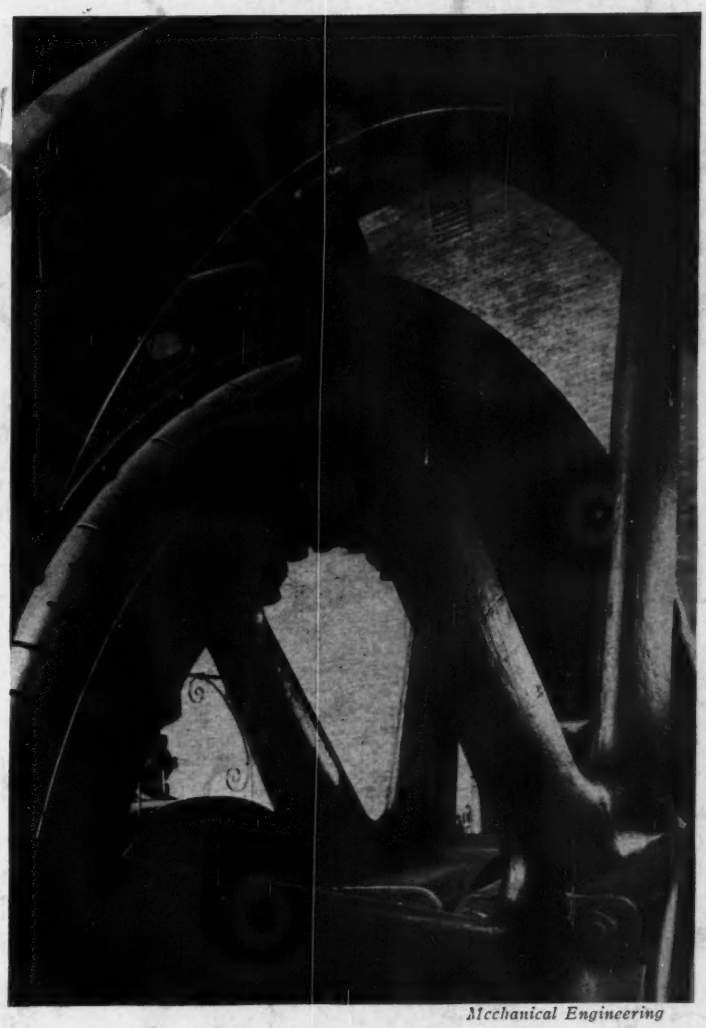
Los Angeles Public Library
MAR 26 1934

APRIL

25 Cents

THE TECH ENGINEERING NEWS

STACK

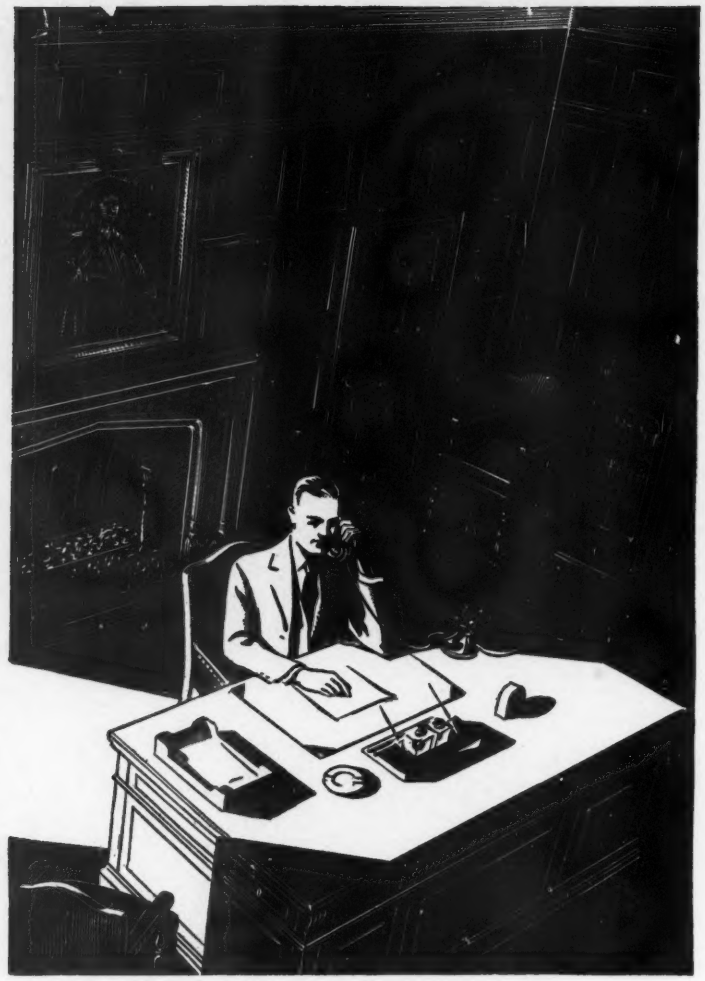


REFERENCE
DO NOT LOAN

Mechanical Engineering

EDUCATION AND ITS RELATION TO VOCATION

MASSACHUSETTS INSTITUTE OF TECHNOLOGY



In five places at once
—by telephone

Conference telephone service—a new telephone convenience—enables a number of people far apart to talk together as freely as though gathered around a table.

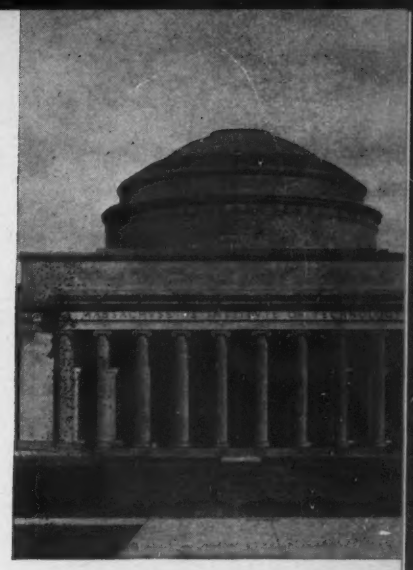
This fosters quicker interchange of ideas in business—saves time and money—expedites decisions. For example: an executive wishes to discuss plans with his district managers. His telephone is connected *simultaneously* with each of theirs—all can talk, all hear everything that is said!

Through constantly developing new uses, Bell System service grows more and more valuable.

BELL TELEPHONE SYSTEM

WHY NOT SAY "HELLO" TO MOTHER AND DAD?
—RATES ARE LOWEST AFTER 8:30 P. M.

THE TECH ENGINEERING NEWS



APRIL, 1934
VOLUME XV
NUMBER 2

. . . CONTENTS . . .

THE COVER: DORMANT POWER
Courtesy—*Mechanical Engineering*

FRONTISPIECE: LIGHT, SHADOW, AND TWISTED STEEL
Courtesy—*Metal Progress*

EDUCATION AND ITS RELATION TO VOCATION - - 23
By William H. Timbie

KEEPING THE SEA IN ITS PLACE - - - - - - 26
By Kenneth C. Reynolds '25

THE DEVELOPMENT OF THE METROPOLITAN REGION 27
By Draveaux Bender '33

ACOUSTICS IN BUILDINGS - - - - - - - - 30
By Jervis C. Webb '37

EDITORIALS - - - - - - - - - - - 32

ENGINEERING DIGEST - - - - - - - - 34

RESEARCH IN REVIEW - - - - - - - - 36

BOOK REVIEW - - - - - - - - - - 37

HENRY J. OGORZALY
General Manager

ZAY B. CURTIS, Jr.
Editor-in-Chief

JAMES D. PARKER
Business Manager

Published monthly throughout the school year, at Walker Memorial, Cambridge A, Massachusetts, by the undergraduates of the Massachusetts Institute of Technology for the purpose of disseminating news of scientific and industrial interest and of promoting closer co-operation between Alumni and undergraduates. Entered as second class matter, June 1, 1920, at the Post Office at Boston, Mass., under the Act of March 3, 1879. Acceptance for mailing at special rates of postage provided for in Section 1103, Act of October 3, 1917, authorized November 3, 1920. Copyright 1934 by The Tech Engineering News. Subscription per year $1.50. Foreign $1.75. Single copies 25 cents.

Metal Progress

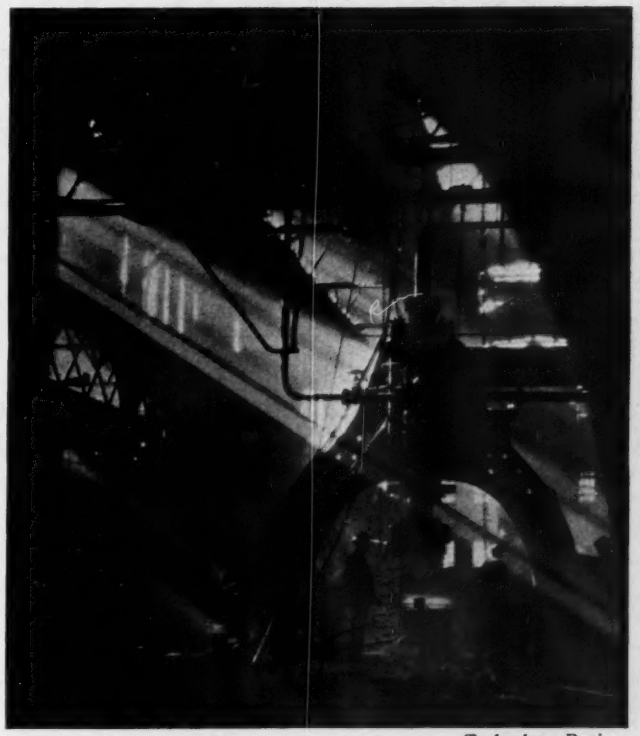
LIGHT, SHADOW, AND TWISTED STEEL

EDUCATION AND ITS RELATION TO VOCATION

By WILLIAM H. TIMBIE
Professor of Electrical Engineering
Massachusetts Institute of Technology

A YOUNG man came into my office recently and gave me the highsign of a Tech alumnus. I recognized him as a graduate, of four or five years' standing, of the Co-operative Course in Electrical Engineering, who had taken his co-operative work with the Boston Elevated Railway. I returned his salute and asked him what he was doing and how he was getting along.

He was in the life insurance business, Vice-President in charge of agency organization and sales promotion, a Director, and a member of the Finance Committee. I laughed and said jokingly, "Well, you are exhibit A of a wasted engineering education. You take a five year course full of higher mathematics, advanced sci-



Technology Review

traffic studies and timetables, experiment on the accelera-teen months qualifying as railway motorman, conductor, and inspector, grub away in the car shops, work over traffic studies and timetables, experiment on the acceleration and control of trolley cars and trains; then you become a life insurance agent. That's my idea of a wasted education."

"You're dead wrong, professor," he came back. "It is just the right education for the job. I needed a stiff course in mental training; I had to learn to think hard, long, and straight. That's how an engineer has to think, and I got the knack and habit of thinking this way by studing electrical engineering for five years. I learned to get the facts and to distrust opinions. Man, I'll never forget the call down one of the fellows got when he used a statement in a popular magazine as an authority to back up an argument. I learned in the laboratory that there are ways of getting facts if you really go after them. As for the time I spent on the Boston Elevated, that was one of the most valuable parts of my education. I mixed with all kinds of men,—lumpers, craftsmen, engineers, and superintendents. I learned the way the other fellow thinks and what his point of view is likely to be on all sorts of subjects. I learned a lot from every one of those Boston Elevated men. Yes sir, the whole course is an ideal training for my insurance work. Why do you suppose they made me Vice-President instead of keeping me working as one of their agents? It was just because I had the advantage of a kind of education that the other fellow had missed, so I could do things he couldn't do."

This young man's story is a rather striking one, but not by any means unique. In fact, it more or less typifies the attitude held by scores of engineering graduates who have found their life work outside of the vocational compartment statically labelled "Engineering."

The usual method of arriving at a figure to designate correlation between engineering education and vocation is to make a survey of engineering graduates and classify them according to whether or not they are in engineering work. In 1923 such a survey was made by Eta Kappa Nu, an honorary fraternity of electrical engineering students and graduates. The distribution of its alumni among the various occupations ought to be fairly typical of the general distribution of electrical engineering graduates. A questionnaire was circulated to 1714 electrical engineering graduates of whom 844 replied. These were listed as to whether they were in electrical engineering, other engineering, or non-engineering. The figures given below are taken from Bulletin 908 of the Investigation of Engineering Education by the Society for the Promotion of Engineering Education, published in 1929.

TABLE 1

Whole Group	*Number*	*Per cent*
Electrical Engineering	518	61.4
Other Engineering	187	22.1
Non-Engineering	139	16.5
	844	100.0
Classes of 1915-22		
Electrical Engineering	377	65.2
Other Engineering	111	19.2
Non-Engineering	90	15.6
	578	100.0
Classes Prior to 1915		
Electrical Engineering	141	53.0
Other Engineering	76	28.6
Non-Engineering	49	18.4
	266	100.0

Technology Review

Table 1. Occupational distribution of Eta Kappa Nu Alumni.

Note that 61.4 per cent of the graduates remained in electrical engineering and that 83.5 per cent were in some kind of engineering. This leaves only 16.5 per cent who were in occupations outside the engineering classification. It is also interesting to note that the graduates of later classes tend to stick closer to electrical engineering than the graduates of the earlier classes and that a smaller per-centage of them are in the non-engineering field. Based on these statistics alone we might be tempted to draw the conclusion that in the Electrical Engineering courses as a whole there is about a 60 per cent correlation between electrical engineering education and vocations which the graduates enter.

An interesting study was made of what the 61.4 per cent were doing who remained in electrical engineering. Table No. 2 groups them according to the functional activities which they occupy in the electrical engineering field.

TABLE 2

Whole Group	*Number*	*Per cent*
Technical	222	42.9
Operation and Maintenance	92	17.8
Administrative	66	12.7
Commercial	100	19.3
Others	38	7.3
	518	100.0
Classes 1915-22		
Technical	174	46.1
Operation and Maintenance	78	20.7
Administrative	30	7.9
Commercial	68	18.1
Others	27	7.2
	377	100.0
Classes Prior to 1915		
Technical	48	34.0
Operation and Maintenance	14	9.9
Administrative	36	25.6
Commercial	32	22.7
Others	11	7.8
	141	100.0

Nearly half (42.9 per cent) go into the technical group, and 17.8 per cent are in operation and maintenance. Also, note the decided shift among the older graduates from these two groups into the administrative group. This is to be expected since administrators are ordinarily drawn from the older graduates. There is also a similar shift among the older classes to the commercial group.

Table 3 shows the occupational distribution of the 16.5 per cent who went into non-engineering work.

TABLE 3

Whole Group	*Number*	*Per cent*
Technical	0	0
Operation and Maintenance	3	2.2
Administrative	74	54.4
Commercial	22	16.2
Others	37	27.2
	136	100.0
Classes 1915-22		
Technical	0	0
Operation and Maintenance	0	0
Administrative	40	46.0
Commercial	15	17.2
Others	32	36.8
	87	100.0
Classes prior to 1915		
Technical	0	0
Operation and Maintenance	3	6.1
Administrative	34	69.4
Commercial	7	14.3
Others	5	10.2
	49	100.0

It is significant that over half of these graduates (54.4 per cent) are in administrative work, while among the older graduates this ratio is a little more than two-thirds (69.4 per cent). A logical conclusion from this table would be that an electrical engineering education is effective in giving a young man the broad fundamental training in habits of thought which fits him for administrative responsibilities even though his duties are not connected with engineering details.

In Table 4 are the results of a survey reported in the Journal of Engineering Education, June 1932. This included graduates of civil, electrical, mechanical, and other engineering courses in land grant colleges, and covered the records of 9334 graduates. In this table graduates classified as being in engineering work included the professional engineers and all others in occupations closely allied with engineering, such as teaching in the engineering field. Note that by this classification 60.2 per cent of all the graduates remain in engineering work.

Technology Review

TABLE 4

ENGINEERING GRADUATES OF LAND GRANT COLLEGES

Years Since Graduation

Type of Training	*1*	*5*	*10*	*15*	*20*	*25*	*30*	*Total*
Civil	568	457	411	477	249	168	150	2,480
Electrical	729	651	331	347	231	157	122	2,568
Mechanical	485	485	285	321	240	135	133	2,084
Other	632	600	217	188	216	144	105	2,202
Total	2,414	2,193	1,244	1,333	936	604	510	9,334
In Eng'g work	1,808	1,516	690	724	493	348	242	5,821
In Eng'g per cent	74.8	74.7	55.4	54.3	52.7	57.7	47.5	60.2

Note here the same drift among the older graduates away from the engineering field into other responsibilities. These figures corroborate those concerning electrical engineers.

The apparent conclusion from such statistics is that the correlation between the education and vocation of a graduate in engineering is only about 60 per cent. But this kind of statistical study is an exceedingly artificial way of testing the correlation between education and vocation. The assumption is made that correlation exists only when a graduate in engineering goes into a vocation that has the tag "Engineering" tacked on to it. This is making the limits of the correlation altogether too narrow. A much fairer criterion of correlation would be to try to answer the question "To what extent does a given college course fit a man for the job; first, as to the habits of thought and action; second, as to the factual knowledge needed for the job?" The college course that does this the best has the closest correlation.

Now concerning an engineering education, it has sometimes been said that the engineer gets his mental training and scientific methods of attack almost entirely upon scientific material; that is, on the facts and theories of mathematics, chemistry, and physics, and therefore he enters his vocation ignorant of the great mass of knowledge and philosophy which constitute the study material of courses in literature, economics, law, and political and industrial history; but let us investigate the facts. Take for instance the course in electrical engineering at the Massachusetts Institute of Technology, the curriculum with which I am most familiar. To be sure the great backbone of the curriculum is a series of subjects dealing with theoretical mathematical physics, but this backbone is augmented and buttressed by courses in English and history, political and industrial, all through the first and second years, the seminar course in Biography in Science in the senior year. There are two courses in Political Economy, at least two general studies from a long list, including Psychology, International Law and American Foreign Policy, Humanics, as well as numerous courses in literature and history, and French and German. In the Cooperative Course two of the required subjects are Business Law and Business Organization.

Just considering subject matter alone, what better array of facts and knowledge could a man bring to his vocation than that represented by a study of such a curriculum. Imagine a conference among four leaders from four outstanding professions, say a lawyer. an economist, a financier, and an engineer. Each must be a specialist in his own particular field, but each should have a broad knowledge of the fields of the others in order to effectively work with them. In my opinion the engineer would know more about the fields of the other three professionals than these three would know about his. I believe that the graduate of an engineering school is more likely, than the graduate of any other professional school, to have the advantage, not only of having had a superior mental training in the analysis of facts, the drawing of concrete conclusions, and in the actual doing of the job, but also of bringing to his task a larger mass of facts and information pertaining to the problem. Don't we read and hear it said over and over again that we live in an engineering world, that modern civilization is built upon the discovery and application of scientific facts and scientific methods? If this is so, then the factual side of one's education should consist of the knowledge of scientific and engineering facts, theories and methods. It is this kind of material that makes up by far the greater part of the curriculum of a modern engineering course, and while we recognize that the prime purpose of an engineering education is not the acquisition of knowledge and facts, but rather the training of a man to think straight, nevertheless, it is true that the very information which he acquires in the process of receiving his training is of such a nature as to be of the greatest possible use to him. In other words, the engineering course as now developed gives the graduate habits of thought by which he is enabled to tackle modern problems effectively, and at the same time furnishes him a mass of information of such nature that it is bound to be of maximum use in his chosen vocation, regardless of what that vocation may be.

But there is another correlation, the nature of which is rather hard to put into words. It is the correlation between the spirit of a man's education and the motives which later should govern not only his vocation but his whole life. If it is important that the factual material and the thought processes acquired at school should be directly applicable to a man's vocation, it is far more important that these mental attitudes and the ideals be

(Continued on page 39)

Technology Review

KEEPING THE SEA IN ITS PLACE

By KENNETH C. REYNOLDS '25
Assistant Professor of Hydraulics
Massachusetts Institute of Technology

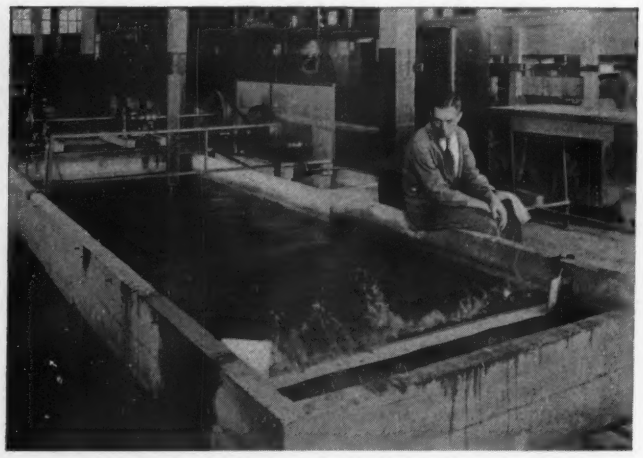
"When I have seen the hungry ocean gain
Advantage on the kingdom of the shore,
And the firm soil win of the watery main,
Increasing store with loss and loss with store;
When I have seen such interchange of state,
Or state itself confounded to decay;
Ruin hath taught me thus to ruminate."

—*Shakespeare*

THERE was a time when the seacoast towns were fishing villages, and the beaches were little used as a place for recreation. As leisure and vacations became a part of the life of the American people—they will be even more so in the future—these seaside resorts were hailed as wonderful vacation spots, and shore properties increased in value. Along the New Jersey coast it is estimated that in 1932 the land had a taxable valuation of over $4,000,000 per mile of coastline. With such property values the need of providing proper protection from the winter storms has been increasingly recognized.

If beaches could be closed up for the season, in so far as wave action is concerned, in a way similar to boarding up summer cottages to protect them against the winter weather, there would be little need for considering the protection of beaches. Such is not the case. Every winter witnesses the storm-driven, mountainous seas hurling their mighty strength against the seacoast and causing millions of dollars of property damage whenever Father Neptune goes on a rampage.

He has at his command three natural agencies for causing this havoc. Wave action, particularly at high tide, is the most powerful. Often a three-day storm occurs near the time of full moon. The ocean rises to unusual levels and for several days the beaches lie open to the attack of the waves. The property damage is heavy. As each wave breaks upon the shore, it runs up the beach as far as possible and then retreats, usually carrying some of the beach material back into the deeper water.



A tea cup ocean and a band of gold — Prof. K. C. Reynolds, '25, shown with the wave maker he constructed in M. I. T. River Hydraulic Laboratory.

If the wave strikes against a barrier, the breaking waves dash high, and buildings, artificial barriers, and piers suffer from the shock of the repeated blows while the huge volumes of water, driven shoreward by the wind, cause further damage, by flooding cellars and hurling stones and sand onto roadways and private properties.

The wind as a second agency of destruction is also responsible for increasing the magnitude of the waves. The third factor is at work wherever there is a coastal current; it is a littoral or coastal drift of the water which moves the sand so that material washed back by the waves is transported for considerable distances. These several agencies cause the shore line of many coasts gradually to recede. In New England with its rock-bound shores this erosion is not so marked as along the New Jersey coast, for example, where it formerly averaged about one and one half feet per year.

To thwart nature's plans, man has erected various types of protective devices which prevent the erosion of the shore line and provide protection to valuable beach properties. The two usual types of beaches are: the headland beaches which are a part of and form the sea boundary of the mainland; and the barrier beaches which consist of islands or peninsulas bounded on the front by the ocean and on the back by some body of water or low marshland which, as properties have been developed, may even be filled in and occupied with dwellings. Much of Revere Beach, Massachusetts, is a barrier beach while parts of Winthrop are headland beach. The barrier beach is often the more intensely developed as a summer resort and yet, because of the low elevation of the land, may be subjected to much severer batterings by the waves.

Several methods have been developed for protecting beaches and even for increasing their area. One, used where sand is being transported by the coastal currents, involves the construction of groins or jetties extending from shore into the water forming pockets to trap the moving sand. They may be made of timber, steel, or concrete, and, as such, are termed groins while similar structures of rock are known as jetties. They are spaced at intervals of a few hundred feet along the shore and usually are at right angles to it. They do not in themselves break up the energy of the wave although, by accumulating sand to form a longer beach, they indirectly furnish a means of dissipating the energy of the wave as it runs up the beach. Such groins are not found on a large scale here in New England since there is a general lack of a combination of a long sloping beach and a strong coastal current which moves material. Groins are used extensively along the New Jersey coast.

Offshore breakwaters break the force of the waves before they strike the shore. Sometimes they are designed to form a protected harbor for pleasure or fishing vessels.

A method of coast defense very common along the New England coast and found along practically all coasts throughout the world is the erection of sea walls along the shore and parallel to the shore line.

The ideal sea wall might be described as a water-

(Continued on page 38)

The Development of

THE METROPOLITAN REGION

By DRAVEAUX BENDER, '33
Harvard School of City Planning

NO longer is the metropolis, that chaotic scramble of skyscrapers, automobiles, street cars, elevateds and subways, economically or socially justifiable. A product of the nineteenth century,—the century of steam power, the iron horse, the factory system, and the horse drawn carriage,—the metropolis is, in our modern civilization, merely a grotesque anachronism perpetuated through the sheer force of its own inertia. It stands, not as a tribute to man's mechanical genius, but as a symbol of man's blind worship of that ethereal concept, the God of Progress. The measure of a civilization is not found in its mechanical perfection but in the condition of mankind and the culture that his mastery of the mechanical world has made possible. It is the use of the machine and not the machine that is vital. We have used ours badly. In an age of electric power, of automobile and truck, of telephone and radio, all capable of so diminishing time and space that there is no need for congestion, we still remain *rooted to the ground* in the same antique spatial relationships as existed in the day of the horse-car. It is nothing less than sheer imbecility to allow the growth of our cities to be dictated by a concept no longer feasible.

Skyscraper — concentrator of economic activity.

An Ideal

Instead of the economically and socially wasteful metropolis, how much better it would be to organize our urban concentrations of population into a more amenable pattern, into urban communities consisting of the focal city and smaller inter-dependent satellites where industry and commerce could be carried on without the wear and tear of congestion as in our present cities. Although this may seem a far-fetched ideal, actually, this process of decentralization of industry and commerce into smaller units is taking place, and the city is gradually assuming a more open pattern. This new urban pattern of focal city and satellites, which is economically and socially integrated into a functional organism of highly specialized inter-dependent parts, is known as the metropolitan region. It is this metropolitan region which we are here considering.

Basic Economic Forces[1]

In order to understand this change in the urban structure, it is necessary to consider (1) the economic basis or urge for urban concentration of peoples, (2) the factors (the machines of the 19th century) which have so conditioned this urge that it has resulted in the present congestion of the metropolis, and (3) the new factors of the twentieth century, the effect of which will be the development of a new pattern of urban structure.

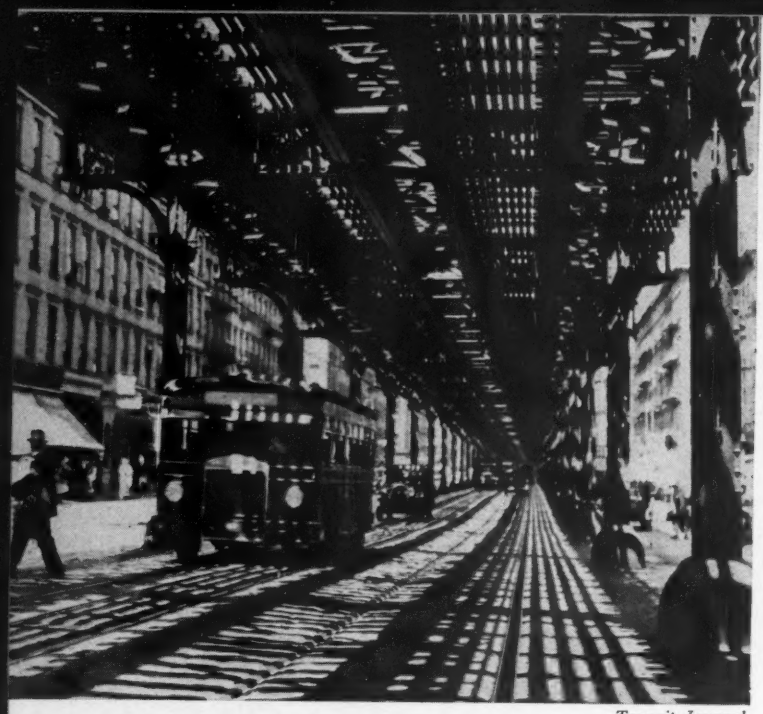
It may be assumed that economic forces are the basis for the general tendency toward concentration of population into urban communities.[2] Secondary forces may be set up within the urban structure once it is established; but these only tend to magnify the basic economic forces or motivating urge. It is essential at this point that we differentiate clearly between the motivating economic urge or causes which tend to create a general urban concentration and the factors which operate upon and so condition that urge that it produces varying species and intensities of urban growth. The factors are the media which translate the causes into structure. They are the tools, the machines, or mechanical processes, if you will, by which the economic phenomenon is carried on. The pattern or structure which they produce varies directly with their varying characteristics. They are the variables to which we look for change, while the economic forces are, within limits, constants. Let us study this economic phenomenon by dividing it into its four component parts: extraction, production, distribution, and consumption, the first two of which may be considered as constituting industry, and the second two as constituting commerce. The processes of extraction, such as mining or fishing, have in their very nature a tendency to concentrate population. However, extractive industries play only a minor role in urban concentration, and we may pass over them without further consideration. The processes of production and their inherent demands necessitate a concentration of population to serve these processes. Production, at least at this stage in the development of the arts, is inconceivable without large supplies of labor, which, in order to reduce the time and space factor of commutation, naturally resolve themselves into a more or less congested pattern contiguous to the production centers they serve. This phase of the economic cycle is perhaps the most important; at least statistics indicate that more people have been involved in the processes of production than in either those of extraction or distribution.

The processes of distribution and consumption may conveniently be grouped together, for, to a great extent, they are dependent upon the transportation structure. Distribution, of course, is the process of carrying goods to markets; and since markets are either other centers of production of different goods and services, or subcen-

---

[1]See Dr. Robert M. Haig's article on "The Economic Basis of Urban Concentration" in Regional Survey of New York, Vol. I.

[2]See Prof. R. D. McKenzie's book "The Metropolitan Community" of the Monograph series for the President's Research Committee on Social Trends.



Transit Journal

Elevated—mass transportation and a factor of a vicious cycle.

ters of distribution for rural markets, the processes of distribution, operating through the medium of the transportation structure, tend to perpetuate and encourage further concentration. The cities of Chicago and New York may be cited as excellent examples of centers of distribution of goods and services to and from both urban and rural centers of production and consumption. Thus we see that the economic forces in each of their four phases tend to produce in general a concentration of population in those areas most favored either in natural resources or because of proximity to markets and favorable transportation facilities.

Factors Creating Concentration in 19th Century

Having clearly in mind the basis for the general concentration of population into urban areas, let us consider those factors which so condition the motivating economic urge that they create within the given general area of concentration that intense concentration of population which we call a city.

These factors may be divided into two general groups: (1) Natural factors of climate, geography, geology and so forth, which are fixed and beyond man's control; (2) Artificial factors, products of man's own handiwork, and consequently within his control. Although the physical factors of climate, geology, and geographical location with respect to raw materials, transportation, and markets may be of far greater importance in determining the general population pattern, they are, however, too general to be of importance within the relatively small region of concentration. They are rather factors creating the general region than they are factors in *determining* the specific form that the population pattern will take within the region. Further, however interesting and vital may be a knowledge of these natural factors, we are here interested in those artificial factors which man may control.

Artificial Factors

(1) *Steam Power*

Undeniably, steam power with its development, making possible the factory and the industrial revolution, has been of tremendous benefit to man, but this form of power, because of its inherent characteristics, has caused an unwholesome concentration of industrial development within the region. It is an inflexible, immobile form of power, requiring for its economical use the high concentration of industry (the processes of production). Its inflexibility has made impossible a healthful decentralization of industry within the region, any part of which for all other factors of location and transportation might be equally desirable.

(2) *Technological Improvement and the Development of Mass Production*

Technological improvement and the expansion of the factory, together with the development of mass production, required the tremendous concentration of population which of course settled as close to the source of employment as possible.

(3) *Mass Transportation*

Without the development of the electric railway, subway, and elevated, the growth of the metropolis would have been impossible. By these media of mass transportation the concentrations of industrial and commercial activity were made possible, and the continued improvement and extension in these forms of transportion only served to intensify the concentration. How could Manhattan Island possibly exist without the subway and elevated to carry the 2,000,000 people that pour into and out of that island daily?

". . . leaping higher, higher, higher, with a desperate desire . . . "—lower Manhattan is a perfect example of ill-planned city development.

Army Ordnance

(4) *The Skyscraper*

Coupled with this development of mass transportation must be linked the development of the skyscraper, made possible by the introduction of the steel frame and the high speed elevator.

Mass transportation and the skyscraper under economic pressure soon geared themselves into a vicious cycle in which they created their own economic phenomena of cause and effect. The skyscraper made possible the concentration of industrial and economic activity, then mass transportation made possible the supplying of this building bulk. With the improvement in the technique of building, more and more building bulk was possible, and with more and more bulk there was the corollary demand, as before, of more and more transportation. Hence we see the phenomena, cause and effect, alternating with each other in the vicious cycle of concentration to supply an industrial pattern that was bound to the earth because of inflexible steam power, and to a commercial set-up created by the industrial activity, and, existing parasitically side by side with it, the super-concentration of both, encouraged by the development of the skyscraper and mass high speed transportation. This growth of the metropolis is the satisfaction of the basic economic urge made possible through the media of man-created factors (his tools and machines), which by their very nature could not fail to produce the metropolis.

Decentralization

No longer need this metropolis exist, for the factors and machines that created it have been superseded by factors of diametrically opposite characteristics capable of decentralizing both the industrial and the commercial structure. The basic economic urge and its general tendencies may remain the same, but the factors that condition the urge have changed. The dominant characteristics of these new factors are flexibility and mobility. Let us examine these new factors.

(1) *Mobility of Electric Power*

It is no longer necessary for industry to hug closely the waterways and railways to get coal for steam power. Through the development of electric power, energy may be transmitted to any part of a region with the greatest ease. No longer need the development of energy and the consumption of energy take place at the same point. A decentralization of industry throughout the region is now possible.

(2) *Mobility of Truck Transport*[3]

No longer are time and space relationships within the region fixed by the major carriers, water and rail. There is now a third and mobile carrier in the field, the auto truck. Through the use of this new medium, many light industries have freed themselves almost entirely from dependence upon direct rail or water connections, and many heavy industries have been given a flexible margin of location.

(3) *Mobility of Labor*

The development of the auto and the improvement in mass transportation which, though now

[3]See Baumgarten—"The Location and Planning of Industrial Areas" in *City Planning*, April, 1933.

Technology Review

Misused distributor of labor.

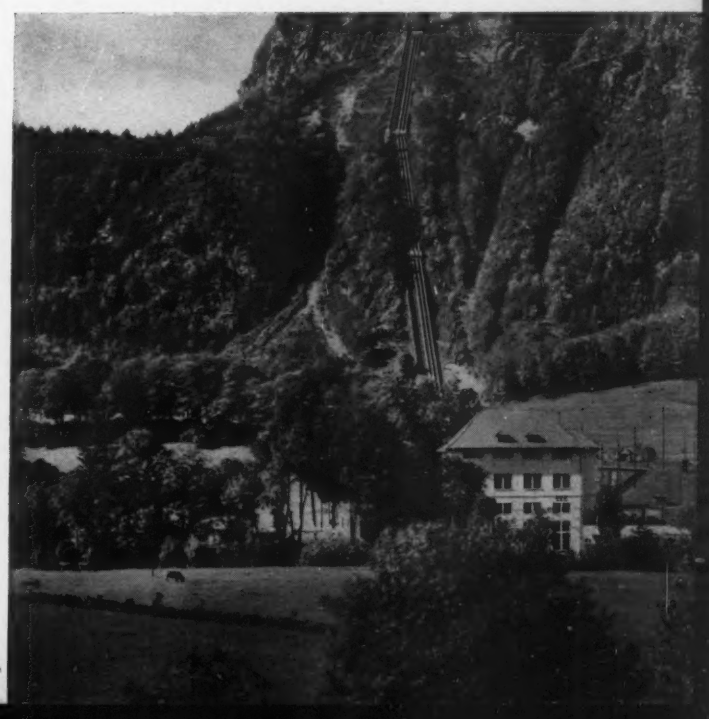
ill-used to create congestion, is capable of being used as our greatest aid to decentralization by facilitating a healthy distribution of labor throughout the region.

(4) *Division of the Processes of Fabrication and Assembly*

In many modern industries the processes of manufacture and fabrication are so related that they may often be separated not only mechanically but spatially. In some cases it may be more convenient and economical for the various parts of a finished product to be manufactured or processed at various points in the region and then brought together at some other point for assembly. This organization, which is commonplace in the automobile industry and saves great waste in transport by reducing bulkiness, is easily applicable to other industries located within the region.

In summation, the essence of these new factors, electric power, truck transport, the automobile, modern mass transportation, and modern processes of fabrication, is their mobility and flexibility making possible the

(Continued on page 40)



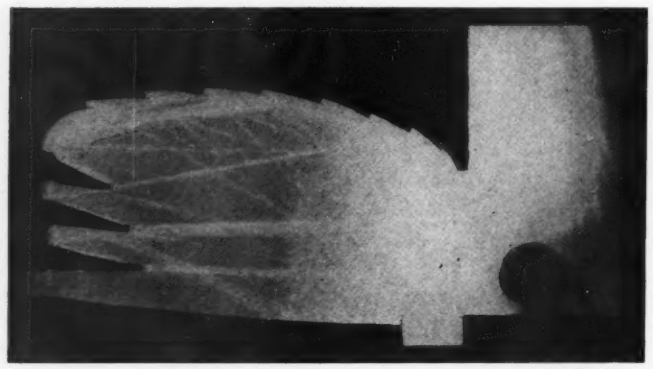
Electricity — a decentralizing force.

ACOUSTICS IN BUILDINGS

By JERVIS C. WEBB '37

THE controlling of reverberations and other acoustical difficulties in buildings has been an important step in the scientific world. As far back as 1898 various scientists went at work on the subject, but although theories were evolved, little application was made of them. In those days when an auditorium was constructed, the architect and the prospective owner could only pray that good acoustics would result. The only prevailing theory concerning the construction of buildings for good acoustics was that a building should be egg-shaped. All auditoriums, however, cannot be oval-shaped and still be useful. Architects realized[1] the fact that good acoustics required homogeneity of atmosphere in a building. They found that heating, ventilating, and lighting systems must be placed so as to give uniform spread throughout the air. Another fact that was noticed even in 1898 was that sound reflectors placed in the so-called "dead spots" of the room improved its acoustics.

At present the science of acoustics is greatly advanced. Complicated formulas have been derived to calculate the optimum point of hearing in auditoriums (the period of reverberation in relation to the volume of a building that will give the best hearing quality). Automatic machines collect the data to be placed in these formulas. The optimum of hearing has been calculated for all types of buildings—music halls, lecture halls, halls frequented by large audiences, and halls having small audiences. Now instead of just praying for good acoustics, the architect may determine the exact acoustic properties of a building while it is still on the drafting board. In old buildings which have been improperly constructed as to acoustics, the modern "acoustical engineer" may step in and by use of sound-absorptive materials and sound reflectors make the building perfect acoustically.



Radio News

Fig. 1 — A cross-sectional model of a miniature theater used to show poor acoustical properties. An auto lamp is used to represent the source of sound. See Fig. 2.

Perhaps a building which was constructed acoustically for lectures is to be used for music. Modern knowledge of acoustics makes the problem of converting the lecture building into one suitable for music quite easy. Recently, the famous pianist, Paderewski, gave a piano recital in the huge Madison Square Garden Auditorium[2] in New York. After the date of the recital had been announced and tickets sold, it was found during the first rehearsal in the auditorium itself that the music was literally scrambled by reverberations. The audience would almost hear the music twice at the same time. Acoustical engineers were set to work. Since Madison Square Garden is two million cubic feet in volume, it was beyond all existing formulas for finding the point of optimum hearing. A few experiments were made. The engineers plotted various curves of sound energy, and, presto, the requirements to make the "Garden" acoustically perfect for music were determined. In addition to various reflectors 47,000 square feet of an absorptive material, rock wool, were laid in sections among the steel girders of the ceiling, and the job was done.

Between the years 1900 and 1910 the science of acoustics made its greatest progress. Although since then advances have been made, fundamental principles evolved during that period are in substance still used today. However, much more practical use is now made of these theories.

The first and foremost pioneer in the science of acoustics was Wallace Clement Sabine,[3] Professor of Mathematics and Natural Philosophy at Harvard University. About 1901, because of Professor Sabine's efforts, the first light on the subject of acoustics appeared. The discovery which led Professor Sabine to experiment with acoustics as a new science was brought about by pure chance.

Sanders Hall at Harvard University was very poor acoustically. Attempts had been made for years to give lectures there, but the reverberation of sound about the hall made it practically impossible to hear what the speaker had said. Finally, since it appeared that nothing could be done, the lectures to be given were transferred to another building. It happened that the seats in this second building were cushioned, and for some reason during the transfer the cushioned seats were removed from this building and placed in Sanders Hall. To the great surprise of all, the acoustics of the other building, which before had been excellent, became very poor. In addition, it was found that the acoustics of Sanders Hall had improved. This phenomenon was brought to Professor Sabine's attention and he became interested in its cause. Perceiving that the change in acoustics depended on the transfer of the cushions, he began to devise experiments to find just what kind of materials did aid acoustics.

He constructed a sound-proof underground room, and in it he placed an organ pipe with the tone middle C, which is the tone of the average human voice. Then he covered the walls of the room with first one material and then another, and he found that the time of reverberation of the middle C tone changed with each material. Attempting to find the duration of reverberation for different materials quantitatively, Professor Sabine soon found that even his clothing had a marked effect on the results he obtained. If he wore a summer suit one day

[1]Kelly, E. H., *Architectural Acoustics*, 1898, pp. 1-12.

[2]Literary Digest, March 26, 1932, p. 37.

[3]Sabine, Wallace Clement, "Collected Papers on Acoustics."

and a winter suit the next day and kept the same material on the walls, the period of reverberation would change noticeably. To eliminate this difficulty, he opened a hole in the wall and kept himself with the exception of his head entirely outside of the room. Soon he found that he could tell when he needed a haircut by perceiving a change in the reverberation for the same material. After a good deal of careful research Professor Sabine found that the time of reverberation of the tone depended on the ability of the material used to absorb sound. Therefore, he calculated coefficients of absorption for all common materials such as iron, brick, glass, stone, felts, and various cloths. Then he tried to improve acoustics in buildings at Harvard by lining their walls and ceiling with some of the more absorptive materials like felt or a cloth. By trial and error he determined how much of a material would be needed to give the best conditions for hearing, and after many tests, he realized that a formula could be made that would make it possible to determine perfect acoustics for a given auditorium in terms of the volume and the area of the room, the velocity of sound at the given temperature of the room, and the average coefficient of absorption of all the surfaces in the room. In substance this formula[4] was as follows:

$$A_1S_1 = \frac{4V \times 2.3 \operatorname{Log}_{10}\left(\frac{E_1}{E_2}\right)}{C\ (T_2 - T_1)}$$

Where,

A_1 is the average coefficient of absorption of walls, ceiling, and floor of the empty reverberation room.

S_1 is the area exposed to sound.

V is the volume of the room concerned.

C is the velocity of sound at the temperature of the room.

E_1 is a certain sound energy level intensity.

E_2 is a subsequent sound energy level intensity.

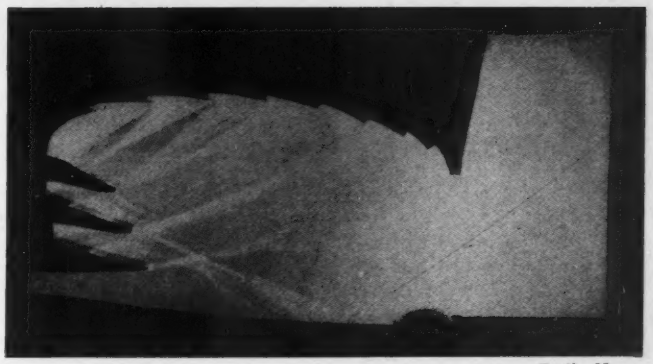
T_1 is the time in seconds corresponding to E_1.

T_2 is the time in seconds corresponding to E_2.

When the absorptive material is added, the left hand side of the formula reads $A_1S_1 + A_2S_2$, where S_2 and A_2 are the coefficients of absorption and area respectively of the absorptive material. Curves plotted with E_1 and E_2 with respect to their times enable one to find the optimum point of hearing in arbitrary energy units. Then the necessary amount of absorptive material is added to balance the equation.

As Professor Sabine's theories became known, ideas on the subject of acoustics began to appear from other men. In Europe systems of placing nets, silk fibers, or wires about the auditorium to improve acoustics were introduced under the assmption that since piano wires resound to notes, perhaps the wires strung in air would resound and so absorb and prevent reverberation. Some said the presence of the wires actually aided the listener, while others were positive that wires did nothing to improve acoustics. In 1912, when asked if they thought that the acoustics of the Royal Cathedral of Berlin were improved by a recent addition of wires strung across the ceiling, the Kaiser said he noticed no improvement whatsoever, and the Kaiserin believed that there was a very marked improvement. On questioning, the janitor of the Cathedral was found to be inclined to side with the Kaiser.[5]

[4]Mackell, James F., *Science* August 28, 1931, pp. 224-5.



Radio News

Fig. 2—The focusing that occurred in Fig. 1 of sound waves represented by visible light on the back of the third balcony has here been removed by acoustical treatment.

Professor F. R. Watson of the Physics Department of the University of Illinois spent several years in Europe endeavoring to find the principle of using wires as an acoustic improver. Returning to America, he stated[6] that the wires in the air stop reverberation as much as a thin pole sticking up in the ocean would stop a tidal wave. Soon the theory of wires and nets being good for acoustics faded quietly away.

The famous physicists, Petzold, Lifshitz, and Vern O. Knudsen of the University of California conducted experiments of their own and obtained results practically identical to those obtained by Professor Sabine thus checking his theory.

Lifshitz and Petzold derived formulas which were much like those of Sabine, and they agreed with him in the experiments he made for finding the optimum point of hearing for a building of given volume.[7] For instance, in a room of 126 cubic meters the optimum time of reverberation after a given sound was, according to Lifshitz, 1.03 seconds, according to Sabine, 1.06 seconds, and according to Petzold, 1.08 seconds.

Dr. Knudsen furthered Sabine's work in that he discovered that ideal acoustics approach the conditions of outdoors. Even the most careful application of absorptive materials he found to yield inferior acoustics to the acoustics of open air.

In 1922 Science Magazine published an article by Henry Gardner and William Downie entitled "Killing Echoes with Paint." The gist of the article[8] was that rough paint finishes help to deflect and absorb sound and so prevent reverberation. They said that sound was analogous to light. When it came against a smooth surface it was, like light, reflected directly back with small loss of intensity, but when it hit a rough surface it was diffused and absorbed as light was. They performed an experiment to prove their theory. Placing a watch at the end of a hollow metal cylinder about three inches in diameter, they found that by covering the interior of the cylinder with various types of finish,

(Continued on page 39)

[5]Watson, F. R., *Science*, May 24, 1912, pp. 833-4.

[6]Watson, F. R., "Acoustics of Buildings," 1923, p. 19.

[7]Watson, F. R., *Science*, March 30, 1928, pp. 338-8.

[8]Gardner and Downie "Killing Echoes with Paint," *Literary Digest*, April 15, '22, pp. 26-7.

THE TECH ENGINEERING NEWS

THE MANAGING BOARD

HENRY J. OGORZALY '35
General Manager

ZAY B. CURTIS, JR. '35
Editor-in-Chief

JAMES D. PARKER '35
Business Manager

NORMAN G. BULL '36
Managing Editor

DORIAN SHAININ '36
Treasurer

DAVID GILDEA '36
Associate Editor

ROBERT E. WILLIAMS, JR. '36
Circulation Manager

BRENTON W. LOWE '36
Associate Editor

SCOTT RETHORST '36
Advertising Manager

Editorial Department

MILTON DOBRIN '36
Technical Editor

BEVERLY DUDLEY '35
Contributing Editor

MARTIN GILMAN '36
Associate Managing Editor

FRANK H. MOORE '34
Contributing Editor

LOUIS SMITH '36
Contributing Editor

Business Department

SIDNEY CORNELL, JR. '36
Publicity Manager

E. HIBBARD SUMMERSGILL '36
Associate Advertising Manager

OLIVER L. ANGEVINE '36
Associate Advertising Manager

VINTON K. ULRICH '35
Personnel Manager

Staff

NICHOLAS AHMADJIAN '37
PAUL ALLEN '37
FREDERICK ALTMAN '37
WILLIAM AUSTIN '37
FRANCIS BUFFINGTON '37
VERN DRESS '37
KENNETH GAIR '37
RONALD GILLIS '37
ROBERT JORDAN '37
WALTER KAUFMAN '37
WALTER KOZAK '37
WILL LYONS '37
WALTER MACADAM '36
JAMES MCLEAN '37
GEORGE MEGERIAN '37
SAMUEL NOODLEMAN '37
JOHN PRIFTAKIS '37
WILLIAM REMALIA '37
JOHN ROBBINS, JR. '37
WALTER SQUIRES '36
JERVIS WEBB '37
LESTER WHITE, JR. '37
HERBERT ZIMMERMAN '37

THE ENGINEERING COLLEGE MAGAZINES ASSOCIATED

Chairman, ROBLEY WINFREY
Iowa State College, Ames, Iowa

Colorado Engineer
Cornell Civil Engineer
Illinois Technograph
Iowa Engineer
Iowa Transit
Kansas Engineer
Kansas State Engineer
Marquette Engineer
Michigan Technic
Minnesota Techno-Log
Nebraska Blue Print
North Dakota State Engineer
Ohio State Engineer
Oregon State Technical Record
Penn State Engineer
Pennsylvania Triangle
Purdue Engineer
Rose Technic
Sibley Journal of Engineering
The Tech Engineering News
Wisconsin Engineer

EDITORIALS

OPEN HOUSE

THE time has once more come when the Combined Professional Societies wish to announce to the public that the Institute's Annual Open House will be held in the Spring. This event, anticipated by thousands of our neighbors, will take place this year on Saturday, May 5, from two to ten p. m., and plans have been developed by the undergraduates of all departments to give all visitors a full day of intermingled entertainment and instruction.

This year's Open House will be the eleventh, and a record number of guests is expected. The affair is planned and operated almost entirely by the students themselves, and almost every undergraduate helps bear the large burden of work so necessary to such a tremendous project. Every effort will be made to have the exhibits and demonstrations appeal not merely to the technical minded, or even to those whose chief interest would be in the spectacular, but to every type of layman and technician alike.

It is earnestly hoped that everyone in the vicinity avail himself of the opportunity Technology students offer to become fully acquainted with the work carried on in the Institute, not only in instruction but also in invention and research. All visitors to past exhibitions seem to have enjoyed themselves greatly, and the Professional Societies promise that the entertainment of the guests will be given prime consideration this year as well. The students of Technology can be of service both to the school and to their community by inviting all of their acquaintances to this year's Open House at as early a date as possible.

ECONOMY IN THE AIR CORPS

THE great American press with traditional sensationalism seized upon the epidemic of crashes of Army planes as the chief angle of the air mail story. And with traditional blindness the press missed the real significance of the accidents, so busy was it quibbling about whether the crashes while flying to new posts should be charged up against Army operation of the mail or not.

The real point is that there *were* crashes while the Army planes were being ferried to new posts. It reveals the extent to which economies have crippled the military air services. The Army is flying obsolete planes with cruising speeds of 140 miles an hour; the commercial air lines are using modern ships with cruising speeds around 180 miles an hour. The commercial planes are equipped with the last word in instruments and safety devices, while the Army is using instruments which are in comparison elementary. In addition and most serious

of all, the present schedule of flying limits military pilots to ten hours a month with no flying in bad weather. It is to the everlasting credit of air corps personnel that, handicapped as they were, they took over the mail with only eight casualties. Yet essentially, the air corps must be an emergency arm ready to act at a moment's notice. Military exigency does not wait for good weather to appear or for slightly rusty pilots to practice.

The air mail situation has caused cries of "legalized murder" to ring in the halls of Congress. It is too bad that those who cried the loudest were using the deaths of pilots not to improve the training of Army pilots but to get back fat mail contracts into private hands. The crime lies not in having the Army fly the mail; it is in the false economy which in emergency puts men in the air with insufficient experience and with fair-weather ships.

EDUCATION IN THE SECONDARY SCHOOLS

A RECENT educational survey of New England secondary schools has revealed an astonishing lack of factual knowledge on the part of high school seniors. The inquiry showed the students to be totally unacquainted not only with the most vital political and economic problems of today but also with the persons who are prominent in world affairs.

Ninety-eight per cent of the students, for example, know of Al Capone, the notorious gangster, but only forty per cent know that Charles Evans Hughes is chief justice of the United States Supreme Court. A surprisingly large number of those tested declared that the gold standard was the flag carried by the '49ers in their rush to California for gold. Only a handful had heard of the Versailles treaty, while "fascism," "proletariat," and "capitalism" were terms unknown to the senior class in the public schools. Communism, in fact, was defined by many of those quizzed as the "propaganda of a group of uneducated and unprincipled people who by the use of bombs and other destructive instruments would overthrow American democracy." Similarly, Nicholas Murray Butler was identified as a famous officer of the marine corps, Stuart Chase as president of the Chase National Bank, and Owen D. Young as a noted historical novelist.

Such results as these indicate the value of revision of the public school system. They show that entirely too much reliance is laid upon ancient academic formulae. If the function of education is to prepare students for living in the modern world, a primary objective in the process must be to acquaint the student with the facts and forces influencing modern life. The secondary schools could contribute definitely to this end by sending on to colleges students who are more aware of the system into which they will have to fit.

INVENTION

IN the past the inventor has been showered with approbation and gratitude for his gifts to society, while the man who used and operated the inventions was kept in the background. Morse, Edison, Ford, and the Wrights all received tributes to their genius. Now with the advent of the new order inventors are subjected to industry; indeed, they are supported, but in return they must forfeit much of their former claim to protection and credit. Their inventions are tied up by industrialists, and the profits accruing from them are sponged upon by patent attorneys and lawyers. Some of those who have flown the oceans, and been feted for it, admit that the feat was purely mechanical on their part. Yet they have reaped much of the credit which should fall to the inventors who have made such tasks possible, and who are not even generally known or accredited with the design of the planes. If invention, which is the backbone of our progress, is to advance or even exist, it must be given "a break"; not only must glory (for glory and credit means little to many men of science who possess the inventative brains) be bestowed, but the results of invention must be made available that we may progress. No man will be inspired to invent that which he suspects may be shelved by the industrialist, and thereby be of no value to civilization.

ENGINEERING DIGEST

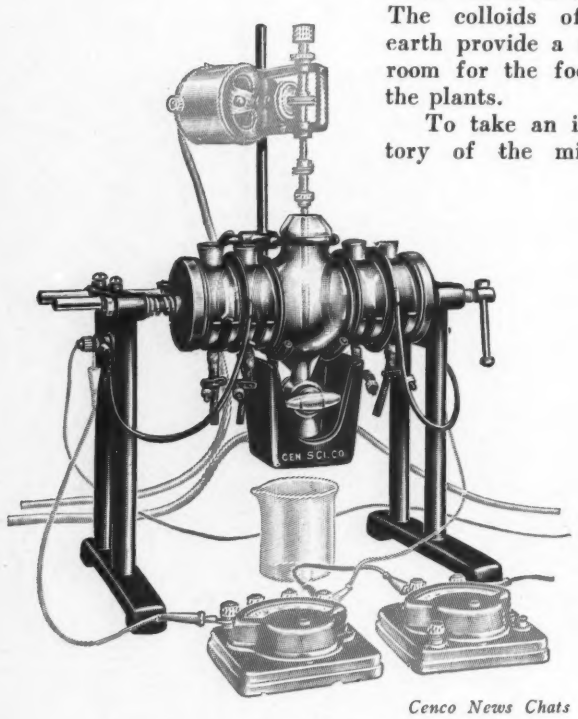
DISGORGING IONS

TWENTY-TWO men line up and intently await the play. The ball is snapped. The players plunge together, a mass of flying arms and legs. Out of the confusion dashes a little fellow. He has the ball! Those little fellows do lots of things that the big ones can't, and it is mostly a matter of size. The smaller the fellow, the harder he is to handle. Carry this matter of size down to really minute dimensions where the little fellow is no longer visible to the naked eye, and then the task begins in making him obey our wishes.

The little "fellows" we have in mind are colloids, minute molecular aggregates, that range in size from 1 mu to 1000 mu. The size of a colloid is rather hard to visualize without having some comparisons. The pores of hardened filter paper are considered very small, but these measure from about 1500 mu to 2000 mu and are much too large for comparison. Colloids would pass right through these pores and would not have to go single file either. Bacteria are just about as small as we can see with the highest power microscopes. They range in size from 500 mu to 1200 mu. It may be said that the smallest bacterium is about the size of a medium large colloid.

No field of colloid investigation is more interesting than that of soil colloids. Most of the older theories have been discarded in favor of the present belief that the colloid content of the soil is the sole factor in making it a favorable place to grow plants. These colloids have remarkable absorptive properties for water and mineral elements. They provide a great reservoir for holding materials needed for the growth of the plant, releasing them only when the need arises. The colloids of the earth provide a storeroom for the food of the plants.

To take an inventory of the mineral elements in the soil storeroom, the exchangeable ions must be pulled out and measured. Electrodialysis has proven the best of the methods of collecting these ions. For reproducible results it is desirable to have the apparatus handle relatively large samples, to operate as rapidly as possible, and to be free from constant attention. The apparatus now developed consists of five special glass compartments, two large platinum-rhodium electrodes, water cooling equipment, and an assortment of various membranes. (*Cenco News Chats,* no. 5, February, 1934.)—E. F. T.



Cenco News Chats

Apparatus for Discharging Colloids.

BERYLLIUM

DEVELOPMENTS respecting beryllium during the last year have awakened industry to the fact that this element is on the way to be the most important of the chemical elements used commercially. The present problem seems to be that of securing an adequate supply of beryllium ore.

Until recent years the cost of producing free berylluim from its ores was prohibitive. Metallurgical research has overcome the great expense to some extent, and now the problem at hand is to find beryllium ores. The chief source of beryllium, beryl, is widely distributed, but there is at present no source capable of producing as much as ten tons per day of pure, gangue-free beryl. This amount of ore would yield about 800 pounds of beryllium metal. The abundance of the ore in nature leads one to believe that the lack is more apparent than real. In the last ten years, shipments have ranged from half a ton to a carload per month, and still the supply exceeded the demand.

Prospectors searching for beryllium ores have many problems before them. The appearance of large beryl crystals which are semiprecious stones (aquamarine beryl) will attract searchers easily but also tend to keep them from considering the extent and the bulk of the deposits. Large deposits of small crystals will be overlooked; while small deposits of the large crystals will be relatively common. As the small crystal affords no distinctive appearance, and as beryllium greatly resembles aluminum chemically, the prospector will have to analyze his specimens very carefully. Valuable deposits have been believed to be low-grade, and analysis has found no ore in some reported deposits. The utilization of hydroxyquinoline (described by Kolthoff and Sandell in 1928) to determine the presence of beryllium has been the most satisfactory method yet discovered.

Chief among the recent commercial developments of beryllium is its alloy with copper. Anaconda and Riverside are already making use of it despite its high price. Stating that beryllium is to copper as carbon is to iron, they cite facts that 2% of beryllium alloyed with copper increases its tensile strength 200,000 pounds, as compared to pure copper. Its resistance to fatigue becomes similar to that of spring steel. The use of beryllium alloyed with other metals, as iron and nickel, seems very promising.

Beryllium oxide, with a melting point of 2570 degrees Centigrade, great strength, low density, extraordinary retention of electrical insulation properties at high temperatures, and high resistance to thermal shock, has

good possibilities as a refractory. Crucibles, boats, electric furnace walls, vacuum tubes, and incandescant light parts can certainly be made of this substance which can be heated and cooled quickly from 2000 degrees Centigrade without injury, and can operate indefinitely in contact with tungsten at this temperature.

Realizing that a large market for beryllium is in the offing, prospectors should be anxious to find large sources of beryllium-bearing ore which may be easily mined and are located near coal deposits or cheap transportation. There are many evidences that this supply may be found. (*Mining and Metallurgy,* vol. 15, no. 326, February, 1934, p. 93.)—J. C. W.

SCIENCE CONTROLS NATURE

RESEARCH chemists have recently developed a new raw material of many uses by subjecting spruce wood pulp to the action of acids, washing, and bleaching baths. This product is commercially available under the generic name of "Solka," and consists of highly purified cellulose obtained from the wood pulp by eliminating almost all of the organic matter which nature builds around cellulose in its natural form. This basic material has wide applications in such widely separated fields as the shoe trade, the manufacture of roofing paper, the weaving industry, and the production of molded plastics.

Yarns and sheets of Alpha cellulose, the technical name for "Solka," are the two general forms produced commercially. The manufacture of the yarn has been the most difficult. Special machinery has been designed to produce a continuous thread from this material. The cellulose fibers are formed into a thread in a manner which might be likened to a cross between the spinning of cotton and the extrusion process used in the manufacture of rayon. The tiny cellulose fibers are lined up almost parallel and are formed into yarn by taking advantage of their natural property of jelling. The threads are twisted into yarn, the amount used varying according to the use for which it is intended.

In producing "Solka" in sheet form the water suspended fibers are felted in a process similar to the manufacture of paper. The felt is pressed and dried into sheet form.

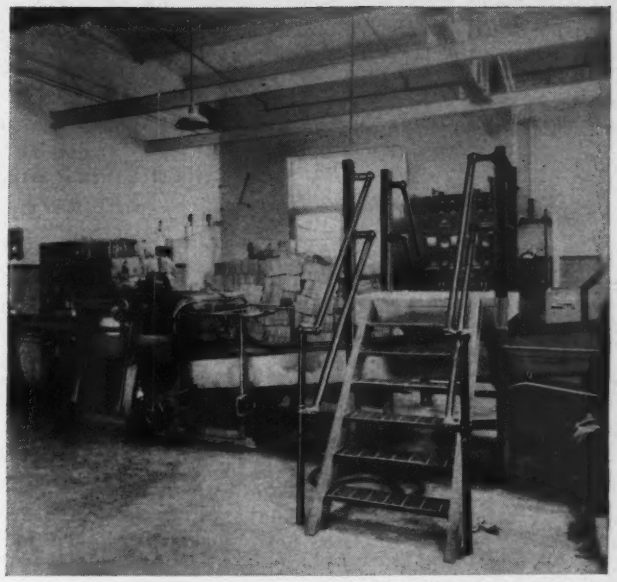
Some of the characteristics that make "Solka" such a desirable raw material to so many industries are: strength, high absorbency, low shrinkage, little stretch, smoothness in yarn, and uniformity of the final product. The development of each of these characteristics may be readily controlled in the manufacturing process, and any single one may be brought out to the greatest extent.

Patient research in the laboratory has made pure Alpha cellulose possible. Further work in both the laboratory and the field should rapidly uncover many more practical uses for it. (*Scientific American,* vol. 150, no. 2.)—R. G.

PERMANENT MAGNETS

PERMANENT magnets have always been an essential part of all telephone apparatus since Bell's first crude devices. Today, they find use in ringers, coin collectors, loudspeaking amplifiers, and numerous other pieces of apparatus.

Permanent magnets, in the form of lodestones or natural magnets, have been known for a long time, and compasses made of permanent magnets have been known for centuries. The exact nature of magnetism is unknown even today, but the generally accepted theory is that magnetic material is composed of countless small magnetic systems, which are like tiny permanent magnets, each having its own magnetic field.



Chemical and Metallurgical Engineering
Cellulose Pulp Macerator.

The electromagnet and the permanent magnet are the two general types of magnets. The former depends on the continuous sources of current which builds up the magnetic field. Such a magnet is readily demagnetized by shutting off the current. Permanent magnets, however, produce their own magnetic fields and are not easily demagnetized. The usefulness of the permanent magnet is measured largely by its ability to retain its magnetism. Moreover, a magnet must be strong enough to create a magnetic field of high intensity.

To determine the properties of a magnet, several values of the magnetic flux density are plotted against the magnetizing force necessary to produce such values. This magnetizing force is varied from zero to a maximum, then to a negative maximum and back to zero. The portion of the resulting curve that is of interest is that in the upper left hand quadrant. That portion is useful in designing permanent magnets. The greater the magnetizing, or coercive force, the greater the resistance of the magnet to demagnetization.

Most magnets are made of carbon steel whose capacity to withstand demagnetization is largely dependent on the percentage of carbon present and on the heat treatment that the steel receives. Certain other elements are usually present also. The combination of elements most favorable for a good magnet seems to be destroyed by heat treatment at high temperatures. The necessary heat treating processes should therefore be carried out in as short a time as possible.

To preserve the structure necessary for good magnetization, carbon steel magnets must be cooled quickly by quenching in oil or water. Unfortunately, if two magnetic characteristics are desired, it is seldom possible to attain a maximum of both by the same heat treatment. A compromise is necessary so that the best possible combination may be obtained.

Permanent magnets rather than electromagnets are used in telephone apparatus chiefly because they do not require a current supply to maintain the magnetic field.

(Continued on page 40)

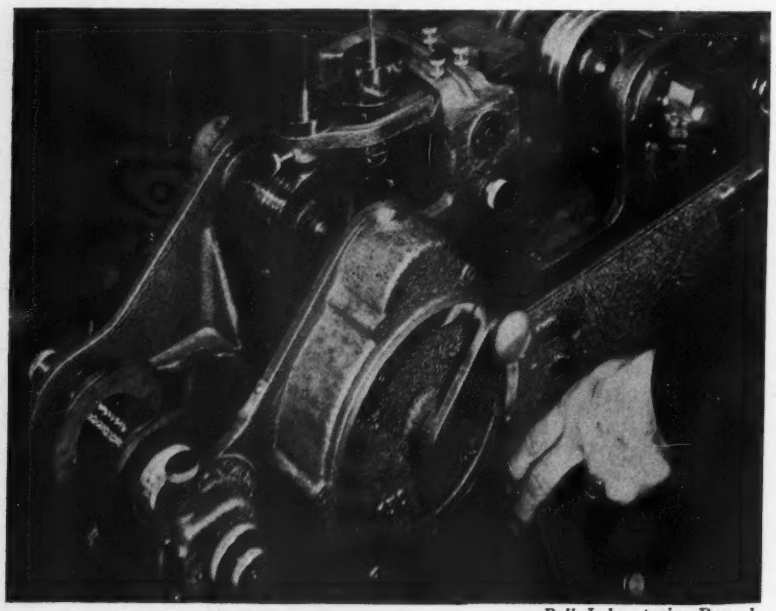
RESEARCH IN REVIEW

COURSE VI — Electrical Engineering

A PROJECT on power-factor characteristics of insulating oils for power cables, carried on for some time, has resulted in the following accomplishments: the development of a bridge for high-precision power-factor measurements of small oil samples, the measurement and evaluation of inherent power factors of air condensers, the development of a test cell for power-factor measurement of small oil samples, and a comprehensive study of power-factor bridge theory. Further research in this field will include the nature of losses on metal surfaces when subjected to an electrostatic field, power-factor measurements and studies of pure synthetic hydro-carbons, and a study of the characteristics of commercial insulating oils.

The determination of stability in large power systems represents an important problem in electric-power engineering, but it is also frequently a complicated and laborious one to tackle. In many instances it involves investigation of the stability and operating characteristics of a long-distance line transmitting power from a new development (for instance, a hydro-station) to an already existing metropolitan system. The latter usually includes a complicated array of transmission and distribution circuits, and a number of generating stations, substations, and loads. From the standpoint of a stability analysis of the transmission system it simplifies the problem and saves time and labor to consider the metropolitan system to which the transmission line ties in ("the receiving-end system") as a unit, and to introduce for it the proper equivalent representation. The latter must be such, of course, that it is sufficiently representative under all conditions and hence leads to results of engineering accuracy. Facilitated by the Network Analyzer this problem is being given attention. With the help of this device it is possible without undue labor to obtain rigorous solutions even for systems of considerable complexity. The rigorous solutions may then be compared with those obtained on simplified premises, *i. e.*, by using equivalent representations of the receiving-end system. Such comparisons establish the degree of accuracy of the approximate methods of attack so that they may be used with justification and confidence.

A project which has been recently completed is the design and construction of a standard signal generator. Such devices are used in practice for radio field-strength measurements and standard broadcast-receiver testing. In the form developed it consists of a stable oscillator covering the broadcast-frequency spectrum, with a buffer amplifier and output amplifier which may be modulated to any desired percentage at audio frequency. Each unit is individually shielded and the device again shielded as a whole. Provision is made for detuning by a known amount for selectivity measurements. Because of the low external field due to careful shielding, the low output impedance, and the inherent frequency stability of the device, it has been found serviceable not only in its regular field but also as a very satisfactory laboratory source of radio frequency.



Bell Laboratories Record

The quality of the enamel insulation on wire, once tested by the thumb nail, is now tested accurately by an automatic recording device.

COURSE XII — Geology

ONE of the most important pieces of work being carried on at present is a continuation of the "Annotated Bibliography of Economic Geology", a work which contains titles of books with short abstracts made by Professor Lindgren, chairman of the volume, and other members of the staff. The material is grouped under the various departments of geology, and the entire collection, published volume by volume, is of inestimable aid to the research student in searching for material. As a token of the valuable work Professor Lindgren has done in the science of geology the American Institute of Mining Engineers has published a splendid volume in honor of him.

Professor Morris and some of his associates are planning to measure the stresses in deep-seated rocks, especially granite, as soon as the snow leaves the ground. Professor Slichter has been working on the mathematical side of geophysical problems and has just completed his study of electric power lines. Professor Newhouse has been studying the microchemistry of liquid inclusion in ore crystals in order to arrive at some conclusions regarding the origin of the ores. Professor Buerger has been continuing his work with X-rays in connection with crystals and their structure. Professor Shimer has just completed a revision of all the rock formations of North America. Dr. Whitehead has been doing further research with oils along with other problems, relating principally to the age of various rocks of eastern Massachusetts and the structural geology of the old mountain system which existed in this region in the period just after the deposition of the rocks around Boston.

BOOK REVIEW

THE TURNING WHEEL—By Arthur Pound, writer of historical and industrial works.

Science and the Motor Age

GREAT corporations were practically forced to enter the field of scientific research in order to protect their market leadership, a supremacy largely dependent upon constant technical improvements, according to Arthur Pound, Industrial historian, in *The Turning Wheel,* a history of General Motors Corporation, just published by Doubleday, Doran & Company. In one chapter Mr. Pound traces the growth of research from the days of pure science, from which no practical benefit was expected, to the present time when nearly every large corporation maintains its own well-equipped laboratory, employing dozens of scientists.

Mr. Pound is also the author of *The Iron Man In Industry, The Telephone Idea,* and other books.

Scientific research up to the beginning of the present century depended upon the means of private investigators or upon universities and foundations for its support, the book says. Pure scientists sometimes "congratulate themselves on the prospect that what they discovered could never be of the slightest use to any one." In this respect, they are defeated men, the author asserts, for the pure science of yesterday usually became the applied science of today.

During research in astronomy, one of the sciences least applicable to human affairs, helium was discovered, and later was found on the earth in such quantities as to make it available as a commercial product. Years of purely scientific research on energy waves preceded the practical application of that knowledge through radio.

Before industry became interested in scientific research, a man upon graduation from the university was usually cut off from laboratory facilities and association with minds keyed to research. "The tendency was for him to consider that scientific progress ended on the day that he lost his contact with it," says *The Turning Wheel.* "A mind of usual resiliency marked the man who, faced with practical problems in engineering, day after day continued to peer behind the veil which hid the unknown.

"The independent inventor and investigator struggled along by himself, without backing, living largely upon hope of developing something patentable. After securing a patent he had to look far and wide for capital enough to bring it to market. Great as the achievements of these men were, industries growing in volume year by year could hardly depend upon such random and choice activities to produce the continuous improvements in technique upon which both earning and market leadership depended.

"Consequently General Motors, in common with other large corporations, took to financing scientific research. While this research concerns itself with long-reach problems involving many branches of science which may be years in process of solution, the engineering staffs of the subsidiaries attack with equal energy the problems involved in improving models from year to year. Not only do the divisional staffs commercialize research findings and ascertain their practical applications, but they also originate and put through important innovations on their own account, either independently or in concert with other staffs."

Keep in Step

with the latest developments in Science and Engineering. Each month

THE TECH ENGINEERING NEWS

presents outstanding articles by authoritative authors. In the past year we have published the writings of the following: Richard Whitney, President of New York Stock Exchange; Charles Abbot, Secretary of Smithsonian Institution; Dr. Arthur D. Little; President Karl T. Compton; Dean Vannevar Bush; Major Chester L. Fordney of the stratosphere-flight fame; Dr. James Aston, originator of the revolutionary wrought iron process that bears his name; Elihu Thomson; and many other well-known educators, executives, and technologists. Our reader is assured of the latest information about advancements in Engineering, Science, and Business. The subscription price is but

$1.50 PER YEAR

SUBSCRIBE NOW TO THE ENGINEERING MAGAZINE OF THE ENGINEERING SCHOOL

Keeping the Sea in Its Place

(Continued from page 26)

tight barrier, erected parallel to the shore line and usually near the high water line, which does not permit any sand, gravel, or water to go over the top, is not excessively high, is not subjected to undermining or to destruction by waves, and is not too expensive to construct. If such a wall is to prevent anything from passing over it when the wave strikes, it will often be so high as to obstruct the ocean view of many property owners, and its cost will be excessive; in this case some compromise from the ideal wall may prove desirable.

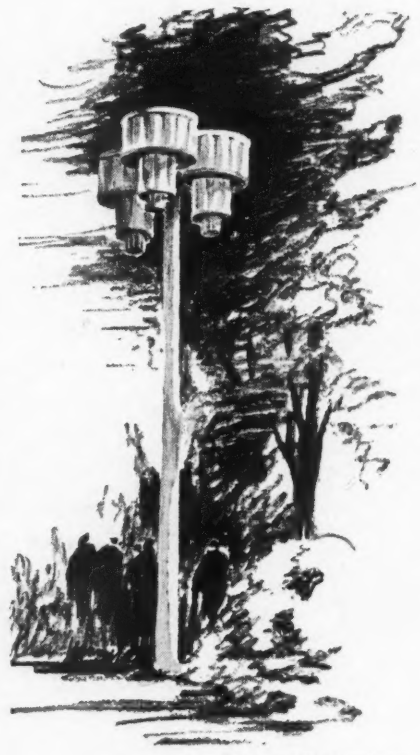
The earliest form of sea wall and the form used even now consists merely of an earthen embankment. Usually it is faced on the sea side with stone. The reclamation of the Zuiderzee necessitated the construction of such a sea wall—in this case called a dike—which was eighteen and one half miles long and was faced with stone to withstand the heavy waves of the North Sea.

Masonry walls with a verticle face, formerly laid up in dry masonry and now made of concrete, are very common. The waves strike against such a wall, a mass of water rises high into the air—a height of fifty feet is not uncommon—and either the water drops down to undermine the wall, or part of it is carried over with sand and gravel to work its havoc on the properties of the beach owner.

This type of wall is being superseded by other types. Three more recent types consist either of a wall with a straight face topped with a curved lip, a wall having a curved face, or a stepped wall with a curved upper portion. These are designed to destroy part of the energy of the waves and throw the water back onto the receding water which acts as a cushion. An example of a straight-faced wall with a curved top is to be found along Winthrop Head, Masschusetts. Wave action on several types are being studied at Helgoland in the North Sea—that beautiful sandstone cliff island in the North Sea with over sixty feet depth of water surrounding it. The wave action is very heavy on this exposed spot.

Another type of wall has steps on the lower part with a curved face on the upper part. Such walls are found along the Atlantic and Pacific coasts and in England, as well as in other parts of Europe. They are of heavily reinforced concrete construction and often are supported on piles with sheeting in front. Such walls tend to fail because of undermining, tipping caused by the back fill becoming saturated, or slipping caused by wave action. The cost of construction is considerable.

How to locate such a wall with reference to the plunge point, what type of front face is best for a given location, what height, how to protect against undermining—these and other problems face the designer. Until recently the engineer has often been obliged to design a wall on the basis of practical experience only. If the location presented new problems, he has used his limited sources of information and has hoped that the new structure would satisfactorily perform its task. If it required correction, it was simply a case of trying out a new scheme until the best solution was attained.



Courtesy Westinghouse

Recently the use of models of a structure has proven to be a valuable tool for the designer. The structure is reproduced in miniature and is studied under conditions similar to nature. Alterations may be easily and inexpensively made until the desired results are attained.

In the River Hydraulic Laboratory at the Massachusetts Institute of Technology studies of sea wall design by the use of models are in progress. A "tea cup" ocean with a concrete-walled basin twenty feet by six feet has a plunger moving vertically up and down at one end so that every stroke produces a wave which runs the length of the basin. It passes up a sandy beach, breaks at the plunge point, and rushes up the beach. As the wave strikes against a miniature sea wall, the water rises into the air and some sand and water are carried over the wall. Measurements are made of the sand carried over and the studies are continued to find that type of wall which will be best for given conditions. The results can be transferred to nature, thus eliminating the great waste now resulting from improper design.

Father Neptune must be kept where he belongs. Our valuable beach properties must be protected from the ravenous waves. "The ocean boundary is a band of gold and must be conserved."

SAMSON SPOT SASH CORD

Trade-Mark Registered U. S. Patent Office

Made of extra quality cotton yarn, carefully inspected, and guaranteed free from all imperfections of braid or finish. The colored spots are our trade-mark. used only with this quality.
We make braided cord of all sizes, kinds, and colors for all purposes, including sash cord, clothes lines, trolley cord, signal cord, arc lamp cord, and many special cords for special purposes.

CATALOGUE AND SAMPLES GLADLY SENT ON REQUEST

SAMSON CORDAGE WORKS : : **89 Broad Street, Boston 9, Mass.**

Acoustics in Buildings

(Continued from page 31)

they could hear the tick of the watch at different distances from the end of the cylinder. Their results were as follows:

Finish of material used inside	Maximum distance heard
Plain metal	40 inches
Sand finish	19 inches
Sponge finish	18 inches
Cork finish	14 inches

In this way they proved that the rough paint finishes absorbed sound.

The world soon began to realize that the science of acoustics was very practical. At first, companies which dealt in roofing or wall materials began to advertise absorptive materials for their advantages to acoustics. Then it was seen that there was a field for men who would apply the formulas of the physicists to architecture. These men would not be physicists, nor would they be architects. They would be "acoustical engineers."

One of the first of these engineers was Clifford B. Swan. Employed by the John's Manville Company, he had the job of improving auditorium acoustics with hair felt for which his company was endeavoring to find a market. With the aid of Prof. Sabine's formulas, he tackled the problem of poor acoustics in every type of auditorium from concert halls to indoor rifle ranges. First, he would determine the amount of absorptive material needed, and then he simply lined the walls of the building with that much hair felt. Once he was of great assistance in improving the acoustics of an army rifle range. A new arsenal had just been built, and in its basement there had been constructed a cement-walled rifle range. When the first shot was fired in the range, several ear drums nearly popped, and no one cared to use that range any more. The acoustical engineer was called in and a thick layer of hair felt was tacked on the walls. As a result, the sound of the rifles in the range became just what it would be outdoors.

Later on in 1923 Swan brought forth an idea[9] for improving the acoustics of an office where the clatter of typewriters, incessant ringing of telephones and buzzers were disturbing. First, he lined the ceiling of the building with a thick layer of hair felt. Then he placed over this an oil cloth of pleasing pattern which was perforated with many small holes. Sound was absorbed, and the acoustics of the office approached the ideal of outdoors.

Other materials beside hair felt came into use. Flax, wood pulp, and artificial stone were some of them. Acoustics were improved by heavy curtains, cushioned seats, absorptive carpets, and decorative covers. Substances like hair felt and rock wool had disadvantages in that the materials were expensive. There was a question as to the beauty of a wall lined with felt, and also there was a fire hazard connected with it. Consequently, the use of rough paint finishes such as those mentioned in a previous paragraph has become more popular.

In the last ten or twelve years, architects have been trained to determine the correct shape of an auditorium and the correct materials to be used in its construction to give good acoustics. Very few buildings have been erected recently that do not have good acoustics. Those old buildings that have defective acoustics are quickly done over into buildings which are perfect acoustically.

The modern knowledge of acoustics is very valuable to the world. It is imperative that theaters, radio stations, and other auditoriums be good acoustically. There is a great need for the quiet rooms in hospitals, hotels, offices, and music studios. If Professor Sabine and the other men who founded this science had not done so, the modern world would have a baffling problem on its hands.

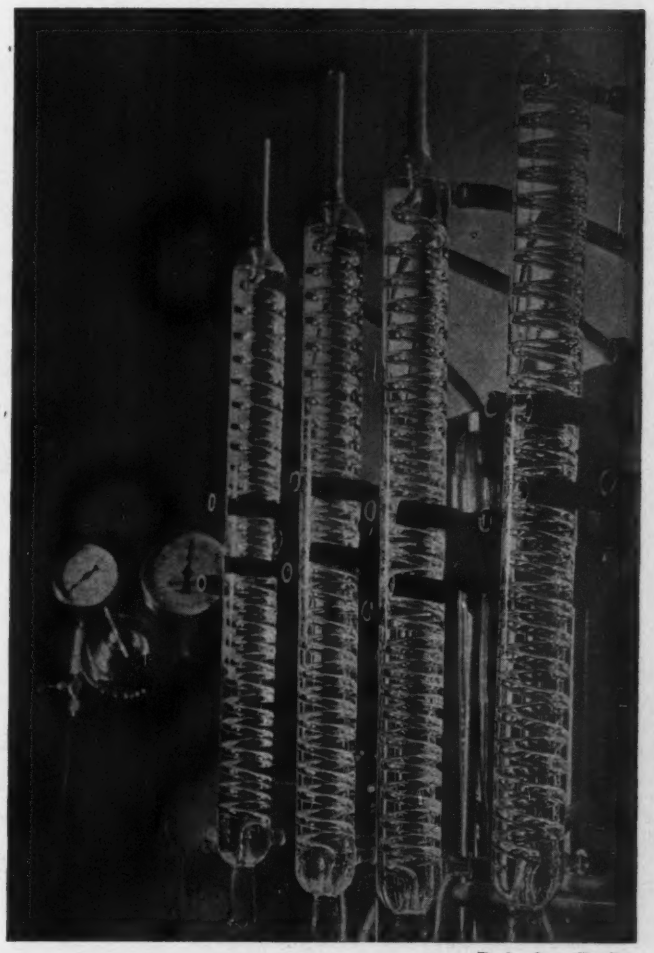
[9]Swan, C. M., *Science*, June 1, 1923, pp. 12-14.

Education and Vocation

(Continued from page 25)

instilled in the student, the application of which in the practice of his vocation will have a beneficent effect upon society. More tritely, when a man's whole life work has been summed up, the world should be a better place to live in as a result of his having lived in it and worked in it.

The unselfish devotion of science and engineering to the constant bettering of mankind's condition is too well recognized to need elaboration. Young men who receive their education in this atmosphere bring to their vocations, however diverse they may be, this traditional spirit of service. Of course, some graduates have caught more of it than others, but few receive four years of engineering training without acquiring some of it. The great need at present is more men with these ideals of science and engineering, and it needs them in every vocation. So whatever vocation he may enter, if the engineer is true to his educational ideals he brings to it the very element most urgently needed by that particular vocation.



Technology Review

The Development of the Metropolitan Region

(Continued from page 29)

decentralization of industry and commerce by reducing *"friction of space."*

Conclusions

This review of (1) the economic basic urge creating the general regional concentration of people in those areas especially favored in climate, raw materials, or transportation, (2) the artificial factors of the nineteenth century,—steam power, mass production and the factory, mass transportation and the skyscraper,—that so conditioned the basic urge that they led to the development of the metropolis and (3) the new artificial factors through the control of which decentralization is possible, leads to the ultimate conclusion that not only is the new metropolitan region a more desirable and healthful form of urban structure, but entirely possible and perhaps inevitable.

The problem of bringing about this new population pattern of the metropolitan region is a challenge to our planning skill. We are just entering a new era in the growth of our cities, and great changes will be wrought in their physical, economic, and social structure. Already we are feeling the "growing pains" of these changes, the results of which are depreciated land values and blighted areas with their grave social and economic repercussions and waste. It is the planner's job to facilitate this change from our now existing congested pattern and structure to the more desirable open pattern of the metropolitan region. The problem is stupendous, a challenge to all the energy, resources, and genius of man.

Cities are not going to perish; urbanization is not going to disappear; the city is a necessary and highly complex organism, which through the use of certain machines satisfies a certain relatively constant economic urge. This urge or drive is unchangeable, but the methods and machines that permitted the satisfaction of that urge are changeable. We, through the application of foresight, may direct those factors and create a city of our own design, a predetermined product of our own handiwork.

In conclusion, we have seen that the primary urge for the concentration of people into general urbanized areas is economic. We have broken down this urge and seen that both industry and commerce are fundamentally concentrating influences. We have seen that this basic economic urge operating during the nineteenth century, and the first two decades of the twentieth, through the media of steam power, the factory, water and rail transport, and the skyscraper and local mass transportation produced a high concentration of population which culminated in the metropolis. We have seen that the basic economic urge can be satisfied by the new mobile and flexible factors (electric power, the automobile, the auto truck, and the division of the processes of fabrication), which, properly directed and controlled, are capable of transforming the concentrated urban pattern into the socially and economically desirable metropolitan region.

We stand at the threshold of a new period in the development of the greatest machine of our civilization—the city. Are we to be its master or its slave?

ENGINEERING DIGEST

(Continued from page 35)

Such magnets are usually made by placing them between the poles of an electromagnet, but special types sometimes require a different procedure. One method is to wind a few turns of copper about the metal to be magnetized and then to blow a fuse which is in series with the copper by sending a very strong current through it. The fuse is blown by connecting the apparatus across a bank of storage batteries. (*Bell Laboratories Record*, vol. 12, no. 5, January, 1934, p. 130.)—P. W. A.

NIAGARA SINGS SOPRANO, BUFFALO BARITONE

IN a noise survey just completed by the E. E. laboratories of New York City for the Buffalo Evening News, it was found that Niagara Falls has a high soprano voice, two or three octaves higher than middle "C" of the piano. New York City and Buffalo, on the other hand, roar baritone, corresponding to less than one octave above middle "C". In both Buffalo and New York City it was found that nearly all the city noise was caused by street traffic; the noise level of New York being about seven decibels above that of Buffalo.

When each portion of the street traffic was considered it was found that Buffalo street cars average about 86 decibels while those of New York only averaged 80 decibels. Buffalo's automobile traffic, however averaged 73 decibels, as compared to the 77 decibels of New York autos. The noise of auto trucks proved to be slightly higher in Buffalo than in New York. The busiest street corner in Buffalo registered 78 decibels while that of New York was 81. The quietest street registered 45 decibels and dropped to as low as 27 decibels at night, the quietest normal street as yet measured in any city. This is comparable to the purr of a cat which has been measured as 25 decibels.

Among some of the extremes of noises found in Buffalo were a railroad train that recorded 102 decibels, a newsboy's whistle of 91 decibels and shout of 84 decibels, while the loudest automobile horn was measured as 93 decibels. (*Electronics*, vol. 7, no. 1, January, 1934, p. 14).—S. N.

NEW HI-WAY DRAG TAPE
FOR HEAVY DUTY ENGINEERING WORK
For body toughness, uniform temper, to best avoid kinking, continued legibility of numbers, and permanence of graduations, it has no equal. Cut at the left is actual size.
SEND FOR CIRCULARS OR GENERAL CATALOG
910
106 Lafayette Street
New York City
THE LUFKIN RULE CO. Saginaw, Mich.

THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY

CAMBRIDGE, MASSACHUSETTS

The MASSACHUSETTS INSTITUTE OF TECHNOLOGY offers Courses in Engineering and Science, each of four years' duration, leading to the degree of Bachelor of Science in:

AERONAUTICAL ENGINEERING
ARCHITECTURAL ENGINEERING
BIOLOGY AND PUBLIC HEALTH
BUILDING CONSTRUCTION
BUSINESS AND ENGINEERING ADMINISTRATION
CHEMICAL ENGINEERING
CHEMICAL ENGINEERING PRACTICE
CHEMISTRY
CIVIL ENGINEERING
ELECTRICAL ENGINEERING
GENERAL SCIENCE
GENERAL ENGINEERING
GEOLOGY
INDUSTRIAL BIOLOGY
MATHEMATICS
MECHANICAL ENGINEERING
METALLURGY
MILITARY ENGINEERING
MINING ENGINEERING
NAVAL ARCHITECTURE AND MARINE ENGINEERING
PHYSICS
SANITARY ENGINEERING

The Course in Architecture is of five years' duration, and leads to the degree of Bachelor in Architecture. Five-Year Co-operative Courses in Electrical Engineering and Railroad Operation leading to the degrees of Bachelor of Science and Master of Science are also offered.

Graduate Courses leading to the degrees of Master of Science, Master in Architecture, Doctor of Philosophy, Doctor of Science and Doctor of Public Health are offered. The Courses leading to the degree of Master of Science include Co-operative Courses in Chemical Engineering Practice and Fuel and Gas Engineering.

The better high schools and other preparatory schools in the United States offer adequate preparation for the required entrance examinations given by the College Entrance Examination Board in June, or by the Institute in September.

Graduates of colleges or of scientific schools of collegiate grade, and in general all applicants presenting satisfactory certificates showing work done at another college corresponding approximately to at least one year's work at the Institute, are admitted to such advanced standing as is warranted by their previous training, and are given credit for our required subjects, including the entrance requirements, so far as they have been satisfactorily completed.

The Summer Session extending from June to September includes most of the subjects given during the academic year and in addition special courses for teachers.

Any of the following publications will be sent free upon request

CATALOGUE FOR THE ACADEMIC YEAR
(WHICH INCLUDES THE ADMISSION REQUIREMENTS)

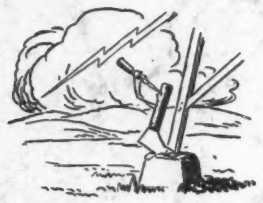
SUMMER SESSION CATALOGUE

GRADUATE STUDY AND RESEARCH

Correspondence should be addressed to the

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

G-E *Campus News*



LIGHTNING SPIES

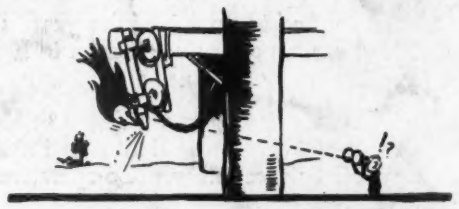
How many amperes are there in a bolt of lightning? Well, there are too many for comfort, and most of us are willing to let the matter rest there. General Electric engineers, however, were very much interested in knowing, so that they could better protect electric transmission lines and equipment from damage by lightning. And last summer they sent out over 2000 little spies. These spies are metal cartridges, hardly an inch long, which were placed on the legs of transmission towers on lines in Pennsylvania and Virginia. This territory is apparently one of lightning's favorite hangouts. When the surge from a lightning bolt passes through a transmission tower, the little spy is magnetized in proportion to the highest current in the bolt. Linemen carry the magnetized spies back to headquarters, where, when placed in a "surge crest ammeter," they tell their story. Many scores of the little spies have reported, and their stories are really shocking. The highest reading has been 60,000 amperes.

Clifford M. Foust, Carnegie Tech, '21, and Hans P. Kuehni, Ecole Polytechnique Fédérale, Zürich, '20, of our General Engineering Laboratory force, were responsible for the spies and the meter to make them talk.

KEYS, MEDALS, AND RESEARCH

The engineers and scientists of the General Electric Company have individually received many keys of honorary societies, medals, and other tokens. On February 1, however, General Electric received a medal to hang on its collective chest. The donor was the 100-year-old American Institute of the City of New York. And the citation read: "For pioneering in industrial research . . . for great achievements in pure science that have furnished gainful occupation for thousands of workers and that have raised the standard of living, and increased health and happiness."

We mention this with pardonable pride, fully aware, however, that medals and honors are not the purpose of research. The real purpose is the discovery of fundamental facts at the border line of man's knowledge. The practical applications are worked out later. It was with this conviction that Dr. Willis R. Whitney, M.I.T., '90, Ph.D., Leipzig, '96, now vice-president of the company, in charge of research, organized the G-E Research Laboratory in 1900. In maintaining this tradition, he is ably assisted by Dr. W. D. Coolidge, M.I.T., '96, Ph.D., Leipzig, '99, the present director; Dr. Irving Langmuir, Columbia, '03, Ph.D., Göttingen, '06, last year's winner of the Nobel prize in chemistry, associate director; Dr. Saul Dushman, U. of Toronto, '04, Ph.D., '12; and Dr. A. W. Hull, Yale, '05, Ph.D., '09, assistant directors.



SOUTHERN SLEUTHING

Not since Cock Robin have our feathered friends figured in a real good mystery, until the other day. And this was not so much a case of violence as of mistaken identity. Down in South Carolina, a power company had been having a little difficulty. It seems that the cutout fuses, which serve the same purpose on electric distribution lines that fuses do in our homes, were blowing out without apparent reason. Finally, an engineer with a Bird Club in his past unraveled the mystery. He saw a bird pecking at the soft fuse wire, apparently having a fine time. (It wasn't a G-E fuse.) Breathless investigation showed that other circuits had been opened in a like manner.

A G-E salesman on his next call recommended our new fuse links. Having copper in that part which the birds attacked, they proved to be im-peckable, and the trouble ceased. Now the birds are concentrating on worms, the power company on G-E fuse links, and everybody is happy.

NRA MEMBER U.S. WE DO OUR PART

96-32DH

GENERAL ELECTRIC